Geodetic Note

Final Report of the Ad Hoc Committee on the Proposed NAVD 88

Introduction

On July 17, 1989, ACSM President James P. Weidener asked Robert Packard to serve as chairman of the Special Committee on NAVD Readjustment—1988 North American Vertical Datum. The committee's charge was to identify areas of agreement and of concern that the user community might anticipate with the adoption of a new national vertical datum. It was pointed out in a letter from Weidener to Packard that ACSM "fully coordinate our activities with the National Geodetic Survey (NGS)and other interested groups." The specific goal and objectives of the committee charge are contained in this letter. It was also understood that because of time constraints requiring NGS to arrive at a specific decision by fall 1990, the final report of the Ad Hoc Committee on NAVD 88 should be submitted to the ACSM president by the first or second days of the 1990 spring meetings in Denver.

In order to address these issues from the broadest possible base, committee members were selected in geographically diverse areas. This included the East Coast (Florida to Massachusetts), the Gulf Coast, the interior of the Southern states, the Great Lakes area, the Plains and Mountain states, and the Pacific Coast (California to Washington). Land surveyors, geodetic surveyors, mappers, and private and government members were included on the committee.

The committee attempted to address the stated goal and objectives, but did not limit discussion of them as questions arose during our analysis and study.

Method of Investigation

The committee membership, with its diverse locations, did not meet until the final report was written on March 17, 1990, in Denver, Colorado. All work was done by correspondence and telephone. The chairman acted as the gathering and distribution point, with all communications being sent to all members. Also, David Zilkoski, NGS, received all the material. This kept the end user of this report (NGS) abreast of the progress and the general thinking of the committee in a direct, yet informal, way. The basic starting document for the committee's review was a "NAVD 88 Datum Definition Study," by Zilkoski, Balazs, and Bengston (NGS). This study briefed committee members on the history of the national vertical network, the principles of a vertical datum, local mean sea level, the geodetic leveling process, leveling error sources and their corrections, and several scenarios as to what could be expected if certain assumptions were made. In these scenarios, the apparent changes from the National Geodetic Vertical Datum of 1929 (NGVD 29) to the proposed North American Vertical Datum of 1988 (NAVD 88) were discussed and plotted for the committee's inspection. This study became the basis of the committee's thought. Despite the diverse locations and perspectives of the committee members, it is hoped that the committee's view of any change in vertical datum would be seen in such a way that no major area or concern would go unnoticed. Though the committee understood that all possibilities could not be addressed in the report, the members felt that the broad needs of the surveying and mapping communities were reviewed, though not specifically addressed, in the final report.

The Report

Identify the state, local government, and private users of the vertical reference system.

The committee was composed of members of each of the identified user groups. Usage varied and seemed

to increase with the size of the user group and the scope of its projects. For the most part, those surveyors who only practiced boundary surveying had little occasion to refer to the national vertical datum, except where flood-plain insurance became an issue.

In some cases a datum defines a shore line, but in other cases the local tidal lines are the determining factor. Where the surveyor is concerned with large public-works projects, the interest in the vertical datum becomes more apparent. Projects constructed in segments that must interconnect and/or where water must flow become very datum-dependent. Larger cities, counties, and states are major users of a national vertical datum. Federal projects, particularly water projects, also are major users of the national vertical datum. Large-scale mapping is dependent on vertical control, and the national network seems to be the datum of choice.

There was some concern among committee members that where NGVD 29, the International Great Lakes Datum of 1955 (IGLD 55), and other vertical datums have been used there would be a tendency to continue to use the older datums rather than NAVD 88 unless there are sufficient ties between the existing and proposed datums. This will be particularly acute in regions where the NGS network has been extended by the U.S. Geological Survey (USGS), the U.S. Army Corps of Engineers (COE), and various other federal and state agencies.

It is the committee's recommendation that these additional vertical networks of NGVD 29 be incorporated into NAVD 88. It is understood that this incorporation, for the most part, would be done by using historical data and not by extensive reobservation. The only viable choice for users of the extended vertical network is to continue with it, as is, until such time as the areas are updated. It is fully understood that programs to convert from one datum to another can never improve or upgrade the original data/observations. However, they may give the user a tool to take advantage of available technology. Considering the expansion of the use of GPS in vertical control, the relationship between the 1929 and 1988 datums will become important in estimating the geoidal separation.

Identify products that use vertical control.

Engineering surveys, topographic mapping, plans for fixed works, deformation studies, and flood-plain studies are general areas that depend on some kind of vertical datum. The size, scope, and types of work; the size of the agency or developer; and the proximity of the project to existing vertical control determine use of a national vertical network.

Engineering surveys and their dependent plans for fixed works and some land/real property boundaries rely on some type of vertical datum reference. Within a given area or region, there should be a common vertical datum. The committee believes that in the definition of the 1988 vertical datum, relationships should be clearly defined between it and the older datums (called datum equations). An extensive educational program will be a must in this area.

Crustal and structural deformation studies extensively use geodetic differential precise leveling. Again, care in defining the relationship between old and new datums is a must. In most cases, the person studying deformation is looking for changes in elevation rather than. absolute elevation; therefore, the datums only are used as a means to an end.

Flood-plain studies can take on several meanings, depending upon who is doing the work, and where. If the study is local in nature, then the datum should be common to any existing topographic mapping and fixed works (structures) in the affected area. In many cases, though, these studies are controlled by datums prescribed by law. The prudent surveyor will tie together the prescribed datum, local datums, and national datums only if control bench marks are sufficiently close to make it economically justifiable. This is a reason to incorporate the USGS/COE networks into NAVD 88.

Existing topographic mapping will be affected depending on the magnitude of the vertical shift, the scale of the map, the topographic relief, and the user requirements for the map information. Good mapping practice calls for both horizontal and vertical datum references on each map. Some existing mapping may only require a note defining the relationship between the mapping vertical datum and NAVD 88.

Education will be required if the surveyor, cartographer, engineer, and other users are to maximize utilization of the various maps and map series available.

Eventually, elevations can be relabeled and minor adjustments made to contours to accommodate the new vertical datum. Complete recompilation of contours may be necessary, depending upon the departure between NAVD 88 and NGVD 29 and on the existing contour interval. Recompilation must be limited due to costs and constraints.

Determine vertical accuracy standards.

The committee felt that the existing Federal Geodetic Control Committee standards and specifications (1974 through 1984) provide sufficient guidelines to meet any foreseeable need. As long as any publication of NAVD 88 elevations includes the order, class, and dates of observation and adjustment of the work, the user can determine if the control bench marks will meet technical needs. The committee, however, perceived a need for specific accuracy requirements that will relate terrestrial leveling and GPS heights. These relationships, methods, and other technological data should be published as soon as possible. In all cases, the surveyor and the user/client must have a clear understanding of scope and use before project-specific standards and specifications can be formulated.

What would be the impact of changes in height values of 0.5 cm, 5 cm, 50 cm, 1 meter, and 1.5 meters?

The committee viewed the changes in heights in part as a psychological barrier. Many areas that experience vertical subsidence and uplift already deal with a similar problem on a regular basis. Though the datum does not change, the bench-mark heights do. Therefore, bench marks may have several elevations, each accompanied by a date of determination, similar to the horizontal datums NAD 27 and NAD 83. The monuments themselves do not change, just the assigned values. Again, dating identifies the epoch of the elevations.

In addition, changes may substantially impact the surveying and mapping services and products. However, some members of the committee felt that a large datum shift value (i.e., 1 meter or more) would iden-ify the difference between datums.

Coastal areas seem to be locations where potential problems will have the greatest effect. Local tidal datums used in harbor and other public-works construction will most likely continue to be used. Lower low water and higher high water are design criteria that affect waterfront construction. Leveling ties to these local datums are most important. The numerical values relating the local datums are important.

Since part of the question is psychological rather than numeric, its solution brings into focus training, education, and information. The first effort in these areas lies with the National Geodetic Survey working with ACSM. NGS staff must prepare comprehensive documentation and make it readily available to the surveying and mapping communities. NGS personnel must also be available to speak at all national and regional engineering, surveying, and mapping conferences. Professional societies must also devote their time and energy to educational programs. Without education, education, and more education, any new vertical datum, regardless of its value, will not be accepted and used.

Document the impact to users of various datum definition scenarios as described in the NGS study.

The NGS study showed several scenarios for the vertical datum definition. There are two basic types. Type one would hold fixed (constrain) a series of bench marks around the country. These marks were generally tidal bench marks that defined, directly related to, observed local mean sea level. Other types of bench marks could also be constrained in this type of definition. Committee members recognized that this would duplicate closely what was done for the 1929 adjustment. This type of scenario would probably produce the smallest numerical change from NGVD 29 to NAVD 88. The committee also recognized that this scheme would create a "warping" effect to the national vertical network. With today's leveling equipment and techniques, warping could be observed and could cause major discrepancies in large projects. Not the least of these conflicts results while attempting to perform vertical (elevation) determinations with GPS.

The second scenario constrains one bench mark as fixed and creates a geopotential system of reference. If an East Coast tidal station (tidal bench mark) is constrained at its local mean sea level, the West Coast heights/elevations appear to be greater than those in the 1929 general adjustment. This

adjustment could be one that might adapt itself well to GPS leveling, provided the geoid height can be modeled properly. This, or some other system, using a simple elevation/height and a geopotential reference surface appears to be a good elevation system and datum system for use into the 21st century.

This is not to say that there are not or will not be problems. There is always an opportunity for problems when any specific bench mark has multiple values for its elevation. A major education/training program is needed to assure that the surveying, engineering, and earth-science practitioners do not intermix data and datums.

The impact of using several tidal marks along both coasts (the procedure employed for NGVD 29) would produce small height changes on the West Coast, but would mean that we would continue to use a "forced fit" datum. The same would seem to be true for the East and Gulf coasts. The real questions are: Do we really want to continue to live with a forced fit datum? What will work best with the future technology of GPS? In most cases, the committee thought it in the best interest of the affected technical and scientific communities not to continue with a forced fit datum, and to make NAVD 88 viable for use with GPS.

Suggest products/services that are needed to assist in the conversion from NGVD 29 to NAVD 88.

The committee felt that without considerable effort on the part of NGS, the datum conversion will be less than successful. The NGS effort must include education, publications, and computer software pro grams. They must "take their show on the road." There must be documentation and computer software readily available.

Specific review was made of the proposed NGS NAVD 88 height listing format. The committee felt that the proposed format would work quite well. There was some discussion about publishing the elevations/heights in feet. If this is to be done, NGS must take into consideration that some states have a legal definition of the foot. Some states use the" International foot, some use the U.S. Survey foot, and some –do not legally prescribe which foot to use. Any NGS publication that uses the unit of the foot must stipulate which meters-to-feet conversion factor was used. In all cases, the metric units would be the fundamental unit.

Documentation should include manuals, benchmark descriptions, orthometric and geoid heights, network maps, and workshop materials. Software should include data gathering, processing, and adjustment programs. Also, approximation programs for bulk conversion are required (such as the NGS horizontal approximation program NADCON).

Conclusion

In the limited time available, the committee reviewed the NGS proposals in "NAVD 88 Datum Study," by Zilkoski, Balazs, and Bengston. All committee correspondence was sent to each member for review and comment. It should be noted that minds were flexible and open to change as more was understood about the process. We therefore make the following recommendations:

1. That NGS defines a North American Vertical Datum of 1988 (NAVD 88) that constrains one bench mark for elevation and that the datum be defined as an equipotential surface through that mark.

2. That consideration should be given to the datum being shifted vertically to minimize recompilation of national mapping products.

3. That NGS compute NAVD 88 elevations for bench marks in the U.S. Geological Survey and U.S. Army Corps of Engineers observed networks.

4. That the National Ocean Service (NOS) integrate vertical network data and tidal datums at NOS tidal stations for access by the surveying and mapping communities through the NGS data base.

5. That NGS develop and publish a national geoid model and PC-based computer software that will relate GPS leveling to NAVD 88.

6. That NGS publish NAVD 88 elevations in meters, U.S. Survey feet, and geopotential units.

7. That NGS develop PC-based software that would convert National Geodetic Vertical Datum of 1929 (NGVD 29), other national vertical datums, and regional/special vertical datums to NAVD 88. These approximate solutions should stipulate error bounds, particularly in sparsely leveled areas.

8. That NGS develop and implement workshops, seminars, lectures, and accompanying literature and documentation to inform and educate the surveying, mapping, and engineering communities, and the general public.

9. That NGS develop national and/or regional geoid models that ensure GPS height differences satisfying second-order, class II, Federal Geodetic Control Committee precise geodetic leveling criteria.

10. That the president of ACSM appoint an ad hoc committee to provide NGS with information and assistance as NAVD 88 is implemented.

11. That NGS compute elevations of all recent geodetic leveling in NGVD 29 with the appropriate caveats for seven years after the date of publication of NAVD 88.

12. That all bench marks, whether destroyed or lost, have published NAVD 88 heights.

Robert F. Packard, chairman
Steven M. Briggs
Steven P. Douty
Steve Estopinal
David Gorgson
James P. Lapsley
John Maxson
Robert McClary
LeRoy Middleton
Sidney C. Miller
Richard J. Mitchell
Charles E. Ogrosky
Herbert W. Stoughton

Surveying and. Land Information Systems, Vol. 50, No. 3,1990, pp. 225-228